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**Severe Liver Trauma with Avulsion of Right Portal Vein And Common Bile Duct.
Case Presentation**

RPV and CBD Avulsion Liver Trauma

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Abstract**BACKGROUND**

Given its size and location, the liver is the third most injured organ by abdominal trauma. Thanks to the recent advances, it is unanimously accepted that the non-operative management is the current mainstay of treatment for hemodynamically stable patients. However, those patients with hemodynamic instability that generally present severe liver trauma associated with major vascular lesions will require surgical management. Moreover, an associated injury of the main bile ducts makes surgery compulsory even in case of hemodynamic stability, thereby imposing therapeutic challenges even in the tertiary referral hepato-bilio-pancreatic centers' setting.

CASE SUMMARY

We present the case of a 38-year-old male patient with a AAST grade VI liver injury with associated right branch of portal vein and common bile duct avulsion, due to crush polytrauma. The patient was referred to the nearest emergency hospital and – because of the hemorrhagic shock – damage control surgery was performed, by means of ligation of the right portal vein branch and right hepatic artery, and hemostatic packing.

Afterwards, the patient was referred immediately to our tertiary hepato-bilio-pancreatic center. We performed: depacking, right hepatectomy and Roux-en-Y hepaticojejunostomy. On the 9th postoperative day, the patient developed a high output anastomotic bile leak that required a redo of the cholangiojejunostomy. The postoperative period was marked by a surgical incisional site incomplete evisceration that was managed non-operatively by negative wound pressure. The follow-up was optimal, with no complication at 55 mo.

CONCLUSION

In conclusion, the current case clearly supports that a favorable outcome in severe liver trauma with associated vascular and biliary injuries is achieved thru proper therapeutical management, conducted in a tertiary referral HPB center, where stepwise and complex surgical approach is mandatory.

Key Words: Severe; Liver; Trauma; Avulsion; Right portal vein; Common bile duct

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Core Tip: The paper analyzes a rare and difficult case of a 38-year-old male patient that presented to the nearest emergency hospital for polytrauma secondary to crush injury, which mainly resulted in a severe liver trauma associated with vascular and biliary injury (grade V liver trauma with severe laceration involving more than 75% of the right hemiliver, injury of the right portal vein and common bile duct). Its management consisted in emergency damage control surgery for hemostasis by vascular ligation and packing in a primary trauma center, followed by major liver resection (right hepatectomy) and biliary reconstruction in a tertiary HPB center. The patient recovered well with no long-term complications and had a follow-up ultrasound that showed no

complications. Currently, the overall survival is 55 mo. In conclusion, the current case clearly supports that a favorable outcome in severe liver trauma with associated vascular and biliary injuries is achieved thru proper therapeutical management, conducted in a tertiary referral HPB center, where stepwise and complex surgical approach is mandatory.

INTRODUCTION

The general term “liver trauma” covers blunt or penetrating abdominal trauma that causes parenchymal hepatic injury and could involve a wide spectrum of intra and/or extra-parenchymal vascular structures and bile ducts (1); the liver is the third most injured organ, given its size and anterior location (2). Other associated organ lesions are found in up to 30% of the cases, usually involving the spleen, the pancreas or the kidneys (3; 4).

The American Association for the Surgery of Trauma (AAST) classification, based on morphologic and imaging criteria, is scaled from I to VI, from the least injury to the most severe, and according to the anatomic disruption characteristics of the liver lesions. Grades from I to V are compatible with survival and represent increasingly complex injuries. Grade VI consists of a destructive lesion, usually incompatible with survival. This classification facilitates the comparison of an equivalent injury that is manageable by several therapeutic conducts (3). The consecutive severity is based on the potential threat to the patient's life. In clinical practice, 80-90% of the encountered liver lesions are minor and moderate (5). Advances of last decades have shifted the mainstay of treatment from exploratory laparotomy to non-operative management (NOM) by multidisciplinary teams in experienced centers (6; 7).

The hemodynamic status, anatomic lesion, as well as associated injuries must be analyzed when deciding upon the optimal management plan (3). NOM is the first choice of treatment in all hemodynamically stable patients with AAST grade I-V injuries, showing no sign of peritonitis or other lesions requiring surgery (8; 9).

However, in clinical practice it is generally admitted that patients with severe liver trauma graded \geq III who present hemodynamic instability after initial fluid resuscitation must undergo an emergency laparotomy aimed at prompt bleeding control (10). Thus, hemodynamically unstable patients should undergo operative management (OM), with major resections only to be considered in subsequent surgical interventions, and not upon the primary surgery setting – that should solely control the hemorrhage and restrict the bile leak (3).

AAST grade V-VI injuries are associated with vascular avulsion and higher mortality rates (11). Vascular avulsion secondary to trauma is very rare and represents a challenge for surgeons, who need to perform damage control surgery, that can include the ligation of the injured vessels (12). Post-traumatic bile duct injuries represent another entity that poses high risk to major complications such as choleperitoneum and biliary fistulas (10).

The CT scan is the gold standard investigation for diagnosing post-traumatic abdominal lesions, having a key role in selecting the treatment strategy (13). However, bile duct lesions pose great diagnostic issues in the post-traumatic setting; literature data suggest that the clinical diagnosis is extremely difficult, and stand-alone CT scanning does not hold an adequate sensitivity for detecting biliary leaks (14); moreover, high morbidity rates are related to a delayed diagnosis, thereby making the early diagnosis crucial (10).

The existing literature offers few studies that report the association between severe liver trauma, right portal vein branch, and common bile duct avulsion, and therefore the present paper is aimed at filling the gaps of knowledge by presenting the management of such a challenging injury.

CASE PRESENTATION

Chief complaints

¹ We present the case of a 38-year-old male patient who was taken to the nearest emergency room with polytrauma due to crush injury, that presented: hemorrhagic

shock due to a grade V liver trauma with severe laceration involving more than 75% of the right hemiliver, avulsion of the right portal vein and common bile duct, with massive hemoperitoneum, right hemopneumothorax, pulmonary contusions, right renal hematoma, II-X rib fractures and left clavicle fracture.

History of present illness

Emergency laparotomy was performed, consisting in ligation and suture of the right portal vein, intentional ligation of the right hepatic artery for hemostasis, drainage of the total biliary fistula (the biliary reconstruction was not considered at this time), and perihepatic packing. Right pleurostomy and closed reduction and immobilization of the left clavicle were also performed. The pulmonary contusions and the right renal hematoma were treated conservatively.

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History of past illness

No significant medical history.

Personal and family history

No significant personal or family medical history.

Physical examination

The patient was then referred 24 h later to our tertiary hepato-bilio-pancreatic (HBP) center for subsequent treatment.

Laboratory examinations

A high-output biliary fistula drained externally was recorded.

Imaging examinations

The CT scan showed no contrast uptake of the right hemiliver in the portal phase, no intrahepatic bile ducts dilatation, no peritoneal liquid and a mild right renal contusion

(Figure 1.A., and Figure 1.B.). A high-output biliary fistula drained externally was recorded.

FINAL DIAGNOSIS

Grade V liver trauma with severe laceration involving more than 75% of the right hemiliver, avulsion of the right portal vein and common bile duct, with massive hemoperitoneum, right hemopneumothorax, pulmonary contusions, right renal hematoma, II-X rib fractures and left clavicle fracture.

TREATMENT

One day after the primary surgical intervention the second operation was performed, consisting in depacking, right hepatectomy and Roux-en-Y hepatico-jejunostomy (using the stump of the common hepatic duct) protected by Wietzel external biliary drainage (Figure 2.A., Figure 2.B., Figure 3.A., and Figure 3.B.). The postoperative CT scan performed in POD 6 showed normal aspect of the remnant liver (Figure 4.A., and Figure 4.B.).

On POD 4, onset of bile output through the subhepatic surgical drain was recorded, that increased progressively to 700 mL/24h in POD 9. On POD 10, surgical reintervention was urged for high output anastomotic leakage. Intraoperative, we diagnosed an anastomotic leakage and dubious vitality of the common bile duct stump. Therefore, we performed a redo cholangio-jejunostomy (using the left bile duct), protected by Wietzel external biliary drainage.

The total intensive care unit stay had a total length of 4 days, as follows: 1 day in the emergency trauma center and 3 days in our center (2 following the operation for right hemihepatectomy, 1 following the intervention for biliary leakage). The patient was administered Piperacillin/tazobactam and Colistin. Blood products was used prior and during the first operation performed in the primary emergency trauma center, as the patient was admitted in hemorrhagic shock. Only 1 unit of blood was used in our

tertiary referral center during the operation for right hemihepatectomy, and none during the operation for biliary leakage.

The postoperative period was marked by a surgical incisional site incomplete evisceration that was managed non-operatively, by means of negative pressure wound therapy (NPWT). The patient was discharged on POD 30, after a remaining uneventful course, with outcare NPWT, until the complete healing of the surgical wound after 4 mo postoperatively (Figure 5.A., Figure 5.B., Figure 5.C., Figure 5.D., and Figure 5.E.).

OUTCOME AND FOLLOW-UP

A follow-up ultrasound was performed at 1, 3, and 6 mo, showing no complications; the external biliary drainage was removed after 6 mo prior to cholangiography control. The patient fully recovered, as there were no other long-term complications encountered; currently the overall survival is 55 mo.

DISCUSSION

Although most liver traumas are successfully treated by NOM, which reduced the morbidity and mortality rates of these patients, interventional therapy still has a role in the management of complex liver injuries.

However, cases of severe blunt liver injury that associate hemodynamic instability after initial fluid resuscitation carry a high risk of hypovolemic shock and death, especially when other abdominal or thoracic lesions coexist; therefore, the current therapeutical conduct in such cases is the operative management (3; 5) (10). In this regard, the main goal of the primary surgery conducted in an emergency setting should be securing efficient hemostasis by damage control surgery (15). In the absence of major bleeding sites, it is usually suitable to employ techniques such as: compression, electrocautery, bipolar devices or suturing the liver parenchyma (16; 17). Major hemorrhage, however, may impose techniques such as: hepatic packing, direct vessel repair under vascular control, vessel ligation, shunting maneuvers, balloon tamponade or hepatic vascular isolation or exclusion (18). Literature data clearly emphasize that

major resections should be avoided whenever possible upon this primary surgical intervention (4).

Studies that have investigated the outcomes of damage control surgery came to the conclusion that the packing procedure is part of a whole “damage control” strategy (19). Even after a well conducted perihepatic packing procedure some patients present active hemorrhage generated from deep injured vessels. In such cases, these patients are managed in the multidisciplinary setting, by selective angioembolization techniques, performed by the interventional radiologists (3). Some severe patients that still present active bleeding following the aforementioned procedures are quickly subjected to a second packing procedure, because time is of essence in order to avoid the onset of the mortality associated “lethal triad” (i.e., acidosis, hypothermia and coagulopathy) (19). The efficient perihepatic packing cannot be defined using an optimal number of gauzes (20); it is although important to avoid excessive packing in order to prevent the abdominal compartment syndrome (19). It is generally considered that packing is best to be removed after 48hrs (21).

When vascular avulsion is present, it is vital to identify the injured vessels. In case of hepatic artery injury, selective ligation is suitable whenever the repairing of the vessel is not feasible. If the right hepatic artery needs to be ligated, cholecystectomy is recommended in order to avoid necrosis of the gallbladder (22; 23); this was not the case with our patient, as he had previously undergone cholecystectomy prior to trauma. When there are injuries of the portal vein, packing or liver resection are preferred to ligation when only segmental branches are affected (17). In our case, the right portal vein was severely injured, imposing its ligation in the setting of damage control surgery, followed by right hepatectomie in the referral HPB center, leaving a sufficient functional liver remnant.

In case of extensive parenchymal damage with insufficient liver remnant, liver transplant is to be considered (23). Liver transplantation completes the therapeutical armamentum, and should be considered the last therapeutic alternative when the previously mentioned procedures prove unable in achieving hemodynamic stability,

and complete hepatectomy is the last resort in bleeding control (1). Literature data on this topic are very scarce (24); nonetheless, the generally accepted indications are: uncontrollable hemorrhage following damage control surgery, extensive and complex hepatic injuries not correctable by surgical procedures, unrepairable injuries of the portal vein, hepatic veins or bile ducts, trauma related acute liver failure due to trauma, and hepatic necrosis (25). The liver transplantation decision should be thoroughly evaluated and implies the identification of those patients unfit for transplant, that present: severe sepsis, multiple system organ failure, or associated severe organ injuries (24), (25).

Liver trauma leads to a great variety of intra- and/or extrahepatic ¹ bile duct injuries; unfortunately, few studies have evaluated the management of bile leakage according to the location of the injured bile duct; therefore, the therapeutical management is controversial (10). Literature states that the moment of detection raises issues of great importance. Because of the vague symptoms at presentation, delayed diagnosis can often occur, leading to high mortality and morbidity rates, through bacterial or fungal peritonitis, intractable bile leakage, haemobilia, pseudoaneurysms, or biliocutaneous fistula, and septic shock (10) (14). Thus, great importance must be given to early detection and proper management of bile leakage following liver trauma (14).

As stated earlier, due to the patient's hemodynamic instability, the goal of the above mentioned primary emergency damage control surgery is to rapidly control the hemorrhage. Studies show that if a bile duct injury is diagnosed upon this primary procedure, the risks of performing extensive procedures such as liver resection and/or bile duct reconstruction are greater than the provided benefits, therefore it is generally accepted that the management of the injured bile ducts will be postponed and conducted at a later time (10).

Recent literature data consider applying adequate therapeutical management according to the extent of the injury and to the bile duct's location. Certain studies have reported promising results following the nonoperative management of *peripheral* bile

duct injuries by using percutaneous drainage procedures and early endoscopic biliary stenting, thus providing a safe alternative and avoiding open surgery (26), (27), (10), (14). Some of the major drawbacks are: the difficulty in performing early ERCP and internal stenting in hemodynamically unstable patients, and post-ERCP cholangitis, resulting in hepatic abscess and consecutive liver rupture (28). In an attempt to overcome these shortcomings, some centers avoided ERCP stenting and stent removal procedures, and adopted first-line percutaneous intraperitoneal drainage; their updated experience shows comparable outcomes (10), (14). Previous studies reporting the setting of severe liver trauma show that peripheral bile duct injuries can be managed by the above mentioned nonoperative treatments. However, the appropriate timing and the choice of therapeutical management are still subject of debate (10), (26), (29), (30).

Recent studies also show that post-traumatic sections of a *central* bile duct are rare and often difficult to diagnose preoperatively (30). The attempt to determine the degree of the bile duct injury with massive fluid collection by means of preoperative CT or MRCP scan is close to impossible (10); therefore, as a diagnostic alternative, some authors promote the use of technetium-99m trimethylbromoisminodiacetic acid scan for early detection on post-traumatic days 5 to 7 (14). Nonetheless, some studies suggest that preoperative CT exam shows a strong correlation between the minimal distance measured from the portal pedicle to the parenchymal traumatic injury and the existence of a bile duct injury (14).

Given the emergency setting scenario of the case under discussion, the MPCR exam was not taken into consideration due to long delays consisting both in waiting list times and examination performing. In addition, a properly conducted perihepatic packing can cause artefacts and major anatomic distortions that render the MRCP exam inconclusive. We considered that intraoperative exploration of the bile ducts combined with intraoperative cholangiography, whenever deemed necessary, is optimal for this type of cases with severe hepato-biliary trauma managed with emergency packing as a first step of the surgical treatment. For example, we did not perform intraoperative

cholangiography, as the surgical exploration of the bile ducts with a malleable metal probe was considered enough.

On the other hand, a *central* bile duct injury will require aggressive surgical treatment, performed once the patient's condition is stable; however, currently, there is no consensual therapeutic conduct available in the literature regarding central bile duct injuries; consequently, the management of such an injury must be tailored (10). Literature data report successful outcomes after techniques such as: liver resection, reconstruction of the injured bile ducts by Roux-en-Y hepaticojejunostomy (31), and /or primary repair of the injured duct with T-tube insertion (32). Biliary leakage by anastomotic fistula is a possible complication, as shown by the current case – i.e., the hepaticojejunostomy was redone in a subsequent intervention. There are also reports available on central bile duct injuries repaired by primary suture and complemented by ERCP and internal stenting as an option for biliary decompression. Due to the extent of the bile duct injury, the concepts of non-operative management were not applicable in the case in question. In addition, even if in retrospect a hepatico-jejunostomy would have been a better therapeutical option, there was no way of knowing this in advance, because the stump of the common bile duct seemed properly vascularized at the time of the first surgical intervention performed in our tertiary referral center. Therefore, at that time an anastomosis performed on the left hepatic duct seemed like an excessive treatment measure.

Given the complexity of the encountered lesions, we did not consider appropriate to adopt any other therapeutic approach. A reconstruction of the right portal vein and right hepatic artery was not considered feasible, because a significant portion of the right portal vein was missing (due to associated trauma and to surgical hemostasis during the damage control surgery), because of the long ischemic time of the right hemiliver, and finally because the parenchyma of the right hemiliver was almost completely damaged by trauma.

Of note, the ligation of the right hepatic artery performed upon the damage control lapatoromy was considered mandatory due to remanent significant

parenchymal bleeding despite right portal vein ligation. Moreover, the right hemiliver was already compromised by the laceration and associated right portal vein avulsion. Therefore, right hepatectomy would have been needed even in the absence of the right hepatic artery ligation.

Negative pressure wound therapy facilitates healing by reducing edema, draining excess fluids, eliminating barriers to cellular proliferation (33), (34). NPWT can successfully promote the healing of infected wounds, diabetic foot wounds, laparotomy incisions, as well as other chronic conditions (35) (36). In our case, it successfully facilitated the closure of the surgical incisional site evisceration allowing for complete healing, thus avoiding the need for additional surgery and exposing the patient to fewer risks.

CONCLUSION

This case clearly supports that a favorable outcome in severe liver trauma with associated vascular and biliary injuries is achieved thru proper therapeutical management, conducted in a tertiary referral HPB center, where stepwise and complex surgical approach is mandatory.

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